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Final Report

for the Period October 1, 1982 - December 31, 1983

Air Quality Technology, Research, Development and Demonstration for Land Management Needs

(USDA F.S. Research Contract No. 28-K2-257)

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1.0 INTRODUCTION

The federal land manager must consider the local and regional environmental consequences of management activities. For example, it has been estimated that 70% of the remaining U.S. oil reserves, 40% of the natural gas, 10% of the known coal and 75% of the oil shale are located on public lands (FEA, 1976). In response to world energy markets, it has been necessary for the federal land managers to accelerate the leasing of mineral resources. When a portion of federal land is considered for development of coal, gas, oil shale or other mineral resource, the land management agency must analyze the potential environmental impact of all phases of development. Local and regional air quality impact is an important consideration in these environmental analyses, and the BLM and Forest Service have recognized the need for in-house capability to conduct state-of-the-art air quality modeling.

Time and cost considerations support an in-house air quality modeling capability. Fire management, disaster assessment, resource planning, and certain leasing situations require a timely, cost effective method for evaluating potential air quality impacts. In-house capability could also support sensitivity analyses and provide quality control that would quantify the uncertainty of air quality modeling results for a variety of applications.

The in-house analysis system must meet specific technical and operational requirements. Much of the mineral resource development area is in the intermountain west where complex topography and the lack of sufficient meteorology and air quality data make air quality modeling a difficult task. Air quality modeling capability must be

sophisticated enough to account for the wind flow and dispersion characteristics of complex terrain. The air quality analysis system must be easily accessible and operated by in-house technical staff. On-line access to necessary data bases is required. Analyses procedures, computer processing requirements and processing time must be cost effective. The system must be flexible and adaptable to additional input, modeling or output capability. In addition, the system must be able to provide analyses products (printed and graphic) which meet land management needs.

For the past several years, the BLM and the Forest Service have supported the development of an air quality analysis system with general requirements that meet the goals of an in-house analysis capability, the Topographic Air Pollution Analysis System (TAPAS). Since October 1982 this development effort has been focused in the Air Quality, Technology, Research Development and Demonstration for Land Management Needs study (Forest Service Research Contract 28-K2-257).

This is the final report for the Air Quality, Technology, Research Development and Demonstration for Land Management Needs study. The report summarizes the study accomplishments from October 1, 1982 through December 31, 1983, and supplements the first and second interim reports (Air Resource Specialists, Inc., 1983a and 1983b) submitted for this study.

The primary goals of the study included:

- o Develop an Analysis System
  - Evaluation, modification, interactive implementation and documentation of wind, air quality dispersion and visibility models

- Evaluation, modification, interactive implementation and documentation of TAPAS support software

o Demonstration of Fully Implemented TAPAS System

The emphasis of this study has been the development, expansion, and documentation of the TAPAS system. All user's guides and documentation are complete and delivered in final form with this report. Accomplishments for all components of the study are highlighted in this report.

2.0 DEVELOPMENT OF THE TOPOGRAPHIC AIR POLLUTION ANALYSIS SYSTEM

2.1 Structure of TAPAS

A principal design objective of TAPAS was to create a high quality modeling environment for scientists and land managers who are not versed in computer operating systems or computer languages. To meet this objective, the TAPAS development philosophy includes:

1. Anyone knowledgeable in the meteorology/air pollution field should be able to run an air pollution simulation model, without obtaining substantial computer training.
2. There is a balance between convenience and computer cost.
3. Related programs in the system of programs should accept the output from any other related program in the system.
4. Any program or model found to be useful will be modified for inclusion in TAPAS and the modifications will most likely not be done by the original authors.

Figure 2-1 is a basic graphic representation of the TAPAS system. It highlights the modularity of the system and the flow of control between TAPAS modules.

TAPAS is easy to apply. Many of the routines are designed for menu-driven interactive application. A real strength of TAPAS is that computed results can be efficiently output as map compatible graphic products. Map compatible graphics provide the land manager with a valuable tool for interpretation and application of model results.

Research and operational applications of TAPAS will continue to be developed. The modularity of the system ensures system flexibility.

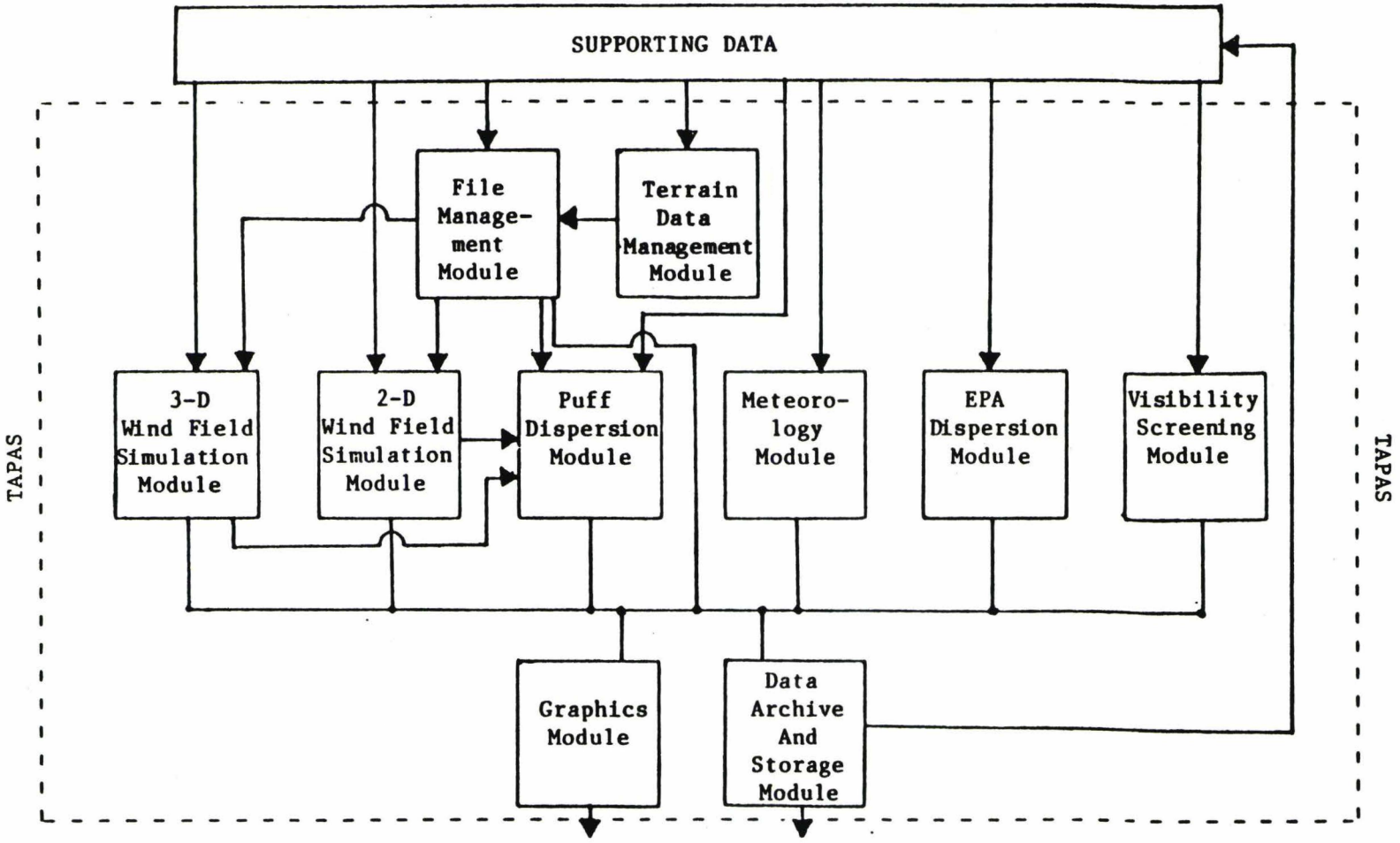

Figure 2-1. Graphic View of the TAPAS System.

New models or other data processing routines can be integrated into the system with minimal effect on the existing programs.

TAPAS is currently implemented on the Colorado State University computer system. The primary computers in the system are the Control Data Corporation (CDC) Cyber 172 and 205 machines. Efficient use of the system requires that the TAPAS users become familiar with a few basic commands associated with the NOS operating system.

User documentation has been written to describe the operational application of each of the ten TAPAS modules. The objectives of the Air Quality, Technology Research Development and Demonstration for Land Management Needs project have been to develop, clearly document, and demonstrate TAPAS. These objectives have been successfully met.

2.2 TAPAS Modules

Figure 2-2 is a Warnier diagram of TAPAS. The diagram details the primary routines within each of the ten TAPAS modules. The TAPAS documentation developed during this project provides detailed descriptions of the design, capability, function, and application of each TAPAS module. Table 2-1 lists the titles of the TAPAS documentation delivered with this final report. The potential TAPAS user is referred to this detailed TAPAS documentation.

As noted in Table 2-1, a TAPAS Overview User's/Programmer's Guide has been developed. The purpose of this manual is to summarize the TAPAS system and assist the user in obtaining, selecting, and applying the necessary TAPAS software to perform specific analysis tasks. An abbreviated description of each TAPAS module was extracted from this

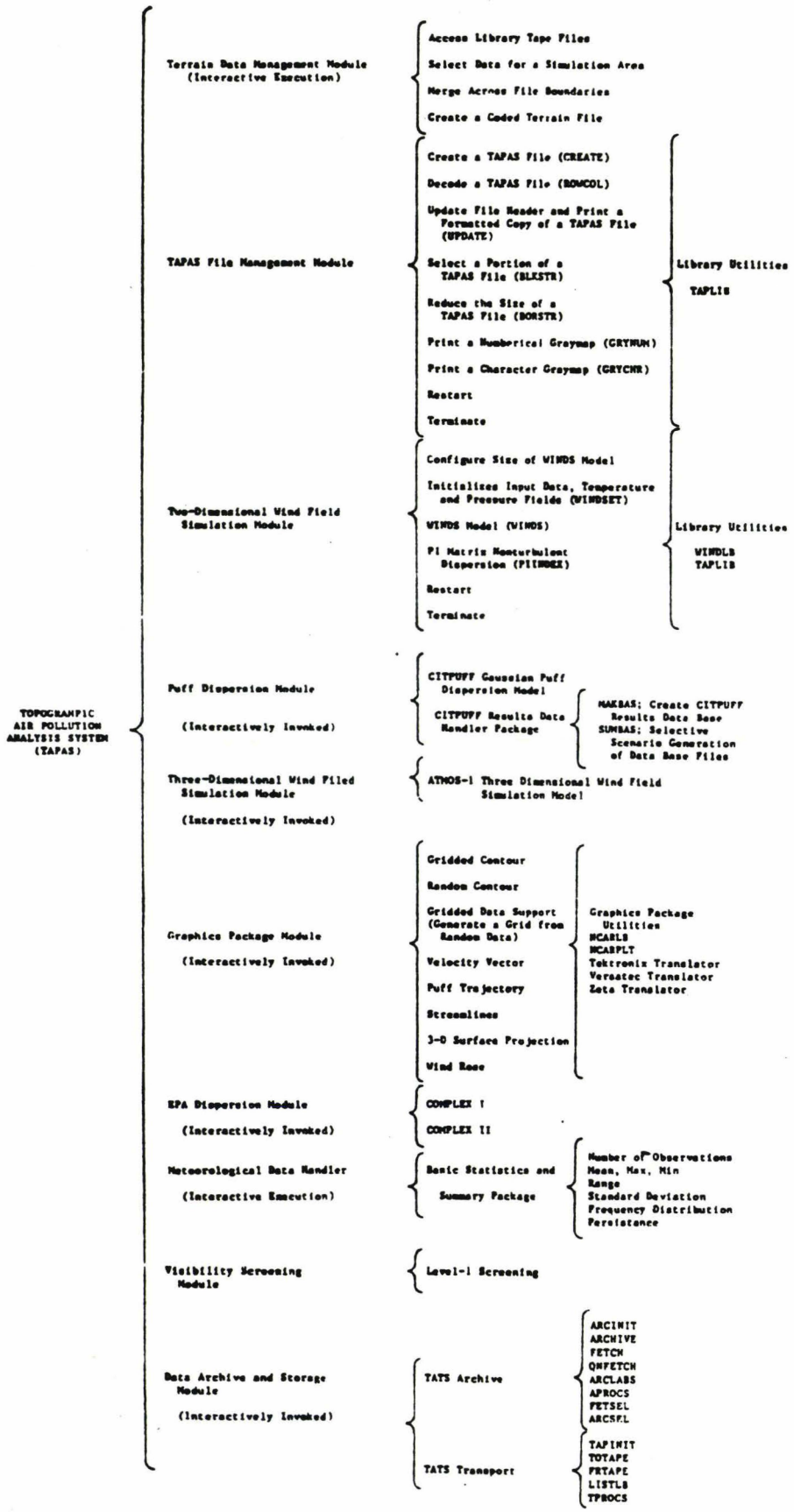

Figure 2-2. Warnier Diagram of the Topographic Air Pollution Analysis System.

Table 2-1. Available TAPAS User Documentation.

Module	Title of Documentation	Pages
TAPAS Overview	TAPAS Overview User's/Programmer's Guide	60
Terrain Data Management Module	User's/Programmer's Guide to the TAPAS Terrain Data Management Module	44 plus 2 Appendices
TAPAS File Management Module	TAPAS File Management Module User's Guide	66 plus 2 Appendices
Two-Dimensional Wind Field Simulation Module	TAPAS Two-Dimensional Wind Field Simulation Module User's Guide	66 plus 3 Appendices
Puff Dispersion Module	CITPUFF: A Gaussian Puff Model for Estimating Pollutant Concentration in Complex Terrain	59 plus 4 Appendices
	CITPUFF Results Data Handler Package	29 plus 2 Appendices
Three-Dimensional Wind Field Simulation	User's Guide to the Three-Dimensional Wind Field Simulation Module	40 plus 3 Appendices
Graphics Package Module	TAPAS Graphics Package User's/Programmer's Manual	55
	User's Guide to the Gridded Contour Graphics Package	30 plus 1 Appendix
	User's Guide to the Gridded Data Support Package	29 plus 2 Appendices
	User's Guide to the Velocity Vector Graphics Package	14 plus 1 Appendix
	User's Guide to the Puff Trajectory Graphics Package	28 plus 1 Appendix
	User's Guide to the Streamlines Graphics Package	26 plus 2 Appendices

Table 2-1 (continued)

Module	Title of Documentation	Pages
Graphics Package Module (continued)	User's Guide to the Three Dimensional Surface Projection Graphics Package	29 plus 2 Appendices
	User's Guide to the Wind Rose Graphics Package	25 plus 3 Appendices
EPA Dispersion Module	EPA Dispersion Module User's Guide	25 plus 1 Appendix
Meteorological Data Handler Module	User's/Programmer's Guide to the METWIX Program of the TAPAS Meteorological Data Handler Module	43 plus 3 Appendices
Visibility Screening Module	User's Guide to the Level-1 Visibility Screening Module	29
Data Archive and Storage Module	TAPAS Data Archive and Storage Module User's Guide	60

Overview manual for inclusion in this final report. The following subsections present these abbreviated module descriptions.

2.2.1 TAPAS Terrain Data Management Module

The TAPAS Terrain Data Management Module supports the digital terrain data requirements of TAPAS. A number of TAPAS models require terrain data. A TAPAS digital terrain library for the continental U.S. was compiled from available NOAA terrain data. The library contains elevation values for every 30-seconds latitude by 30-seconds longitude. The TAPAS Terrain Data Management Module provides a user with the interactive capability to extract terrain data from the data library.

Figure 2-3 is a flow chart of the principal processes in the Terrain Data Management Module. Required inputs are the longitude and latitude corner coordinates of a desired area and the required grid point spacing. Terrain data for a user selected area is output as a formatted, coded file. The TAPAS Terrain Data Management Module User's Guide describes the application of the module in detail.

2.2.2 TAPAS File Management Module

The TAPAS File Management Module supports inter and intra-TAPAS data transfer, prepares external files for TAPAS processing, and helps users verify that input data for TAPAS routines are reasonable and consistent.

The module contains seven principal routines. The routines are listed and briefly described in Table 2-2. A flow chart depicting the relationship among these seven routines is provided as Figure 2-4. The TAPAS File Management Module User's Guide describes the application of the module in detail.

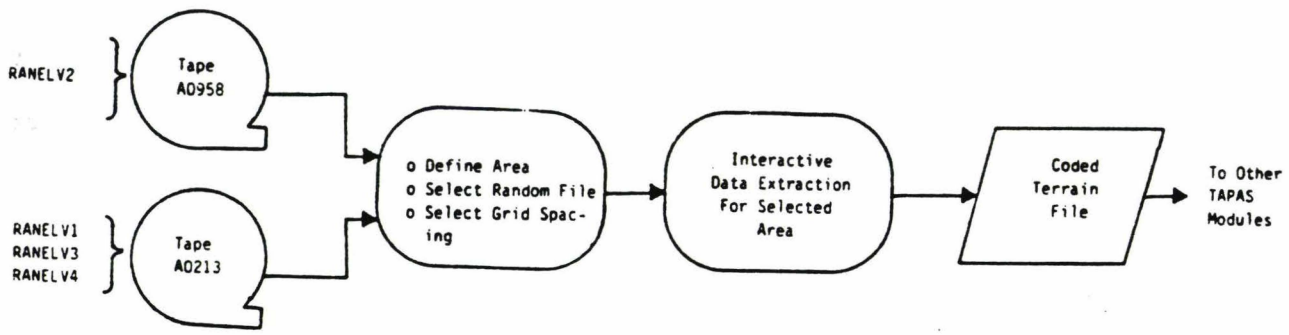

Figure 2-3. TAPAS Terrain Data Management Module Flow Chart.

Table 2-2. List of Routines in the TAPAS File Management Module.

Number	Operation	Description
1	Create TAPAS File from Row-Column	Requests the information required to run Program CREATE which converts a row-column formatted array data file into a TAPAS structured file. TAPAS structured files are required by many TAPAS routines.
2	Grey Map - numerical data	Requests the information required to run Program GRYNUM which takes a TAPAS structured file and generates a grey map representation of the numerical information on the numerical designated file.
3	Grey Map - character data	Requests the information required to run Program GRYCHR which takes a TAPAS structured file and generates a grey map representation of the character information on the designated file.
4	Row-Column Convert from TAPAS	Requests the information required to run Program ROWCOL. ROWCOL converts a TAPAS structured file into a row-column formatted file.
5	Update File Heading	Requests the information required to run Program UPDATE. This routine gives the user control over the user selected TAPAS structured file heading and allows the user to print the contents of a file in user selected format.
6	Block Strip a File	Requests the information required to run Program BLKSTR. Block stripping a file means to extract a portion of a TAPAS structured file as defined by user selected minimum and maximum X and Y values for use by another routine.

Table 2-2 (continued)

Number	Operation	Description
7	Border Strip a File	Requests the information required to run Program BORSTR. Border stripping a file is to remove all of the data along the top and bottom rows and left and right columns.
8	Restart - Erase Previous Input	Provides the user with the option of erasing the input information from this interactive session and restarting the session.
9	Terminate Supervisor Session	Instructs the Supervisor to put the job created during an interactive session into final submit file form.

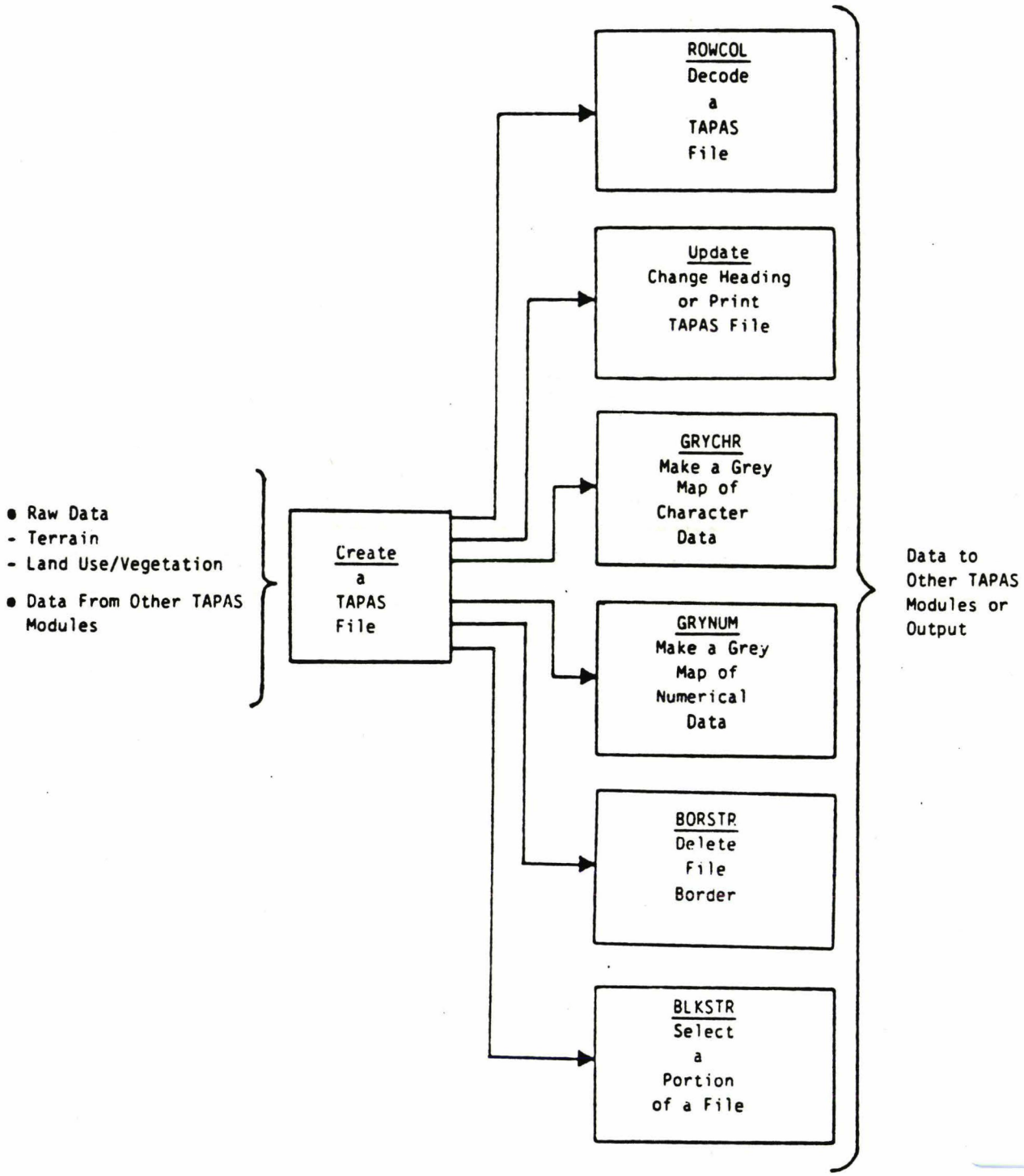
• Raw Data
- Terrain
- Land Use/Vegetation
• Data From Other TAPAS Modules
Create a TAPAS File
ROWCOL Decode a TAPAS File
Update Change Heading or Print TAPAS File
GRYCHR Make a Grey Map of Character Data
GRYNUM Make a Grey Map of Numerical Data
BORSTR Delete File Border
BLKSTR Select a Portion of a File
Data to Other TAPAS Modules or Output

Figure 4-3. TAPAS File Management Module Flow Chart.

2.2.3 TAPAS Two-Dimensional Wind Field Simulation Module

The TAPAS Two-Dimensional Wind Field Simulation Module supports the application of the WINDS model and a Pollution Dispersion Index. The WINDS Model simulates a two-dimensional wind field in complex terrain. The Pollution Dispersion Index applies the results of the WINDS model to estimate a maximum allowable emission per grid cell based on user defined standards and conditions.

The module contains four principal routines. The routines are listed in Table 2-3. A flow chart depicting the Two-Dimensional Wind Field Simulation Module processing steps is provided as Figure 2-5. The TAPAS Two-Dimensional Wind Field Simulation Module User's Guide describes the application of the module in detail.

2.2.4 TAPAS Puff Dispersion Module

The TAPAS Puff Dispersion Module supports multiple source puff-type dispersion analyses. The module contains two major packages, the CITPUFF Model and the CITPUFF Results Data Handler Package. Puff model analysis is performed using the CITPUFF model. Terrain, meteorological and source emission data along with WINDS model results are used by CITPUFF to estimate plume transport and dispersion from multiple sources. The CITPUFF Results Data Handler Package can be used to combine several CITPUFF Runs or any other TAPAS structured files for an analysis area. Source emissions and the number of considered sources can be varied within the Results Data Handler to simulate a range of development scenarios.

Figure 2-6 is a flow chart of the principal processes in the Puff Dispersion Module. The TAPAS Puff Dispersion Module contains two

Table 2-3. List of Routines in the TAPAS Two-Dimensional Wind Field Simulation Module.

Number	Operation	Description
1	WINDS Configure	This routine requests and uses the information required to reconfigure the WINDS model code for any user selected analysis area grid size. The routine edits the model code and compiles the newly configured WINDS model program
2	Wind Set	This routine requests the information required to run the WNDSET program. WNDSET uses an elevation file and a vegetation file in TAPAS format (as generated by the program CREATE) and user defined meteorological boundary conditions to generate a file with elevation, vegetation, potential temperature, and non-dimensional pressure arrays. The file generated by WNDSET is required as input for the WINDS model
3	WINDS Model	WINDS is one of the major models of TAPAS. The WINDS model generates a two-dimensional wind field and a mixing volume index. WINDS results can be used by other TAPAS programs such as CITPUFF and Pi Matrix
4	Pi Matrix	This routine requests the information necessary to run the program PINDEX. The Pi-Index provides an estimate of the amount of effluent that can be emitted within the user's simulation area without exceeding a user selected standard

Table 2-3 (continued)

Number	Operation	Description
5	Restart-Erase Previous Input	Provides the user with the option of erasing the input information from the current interactive session and restarting the session
6	Terminate Supervisor Session	Instructs the Supervision to put the job created during an interactive session into final submit file form

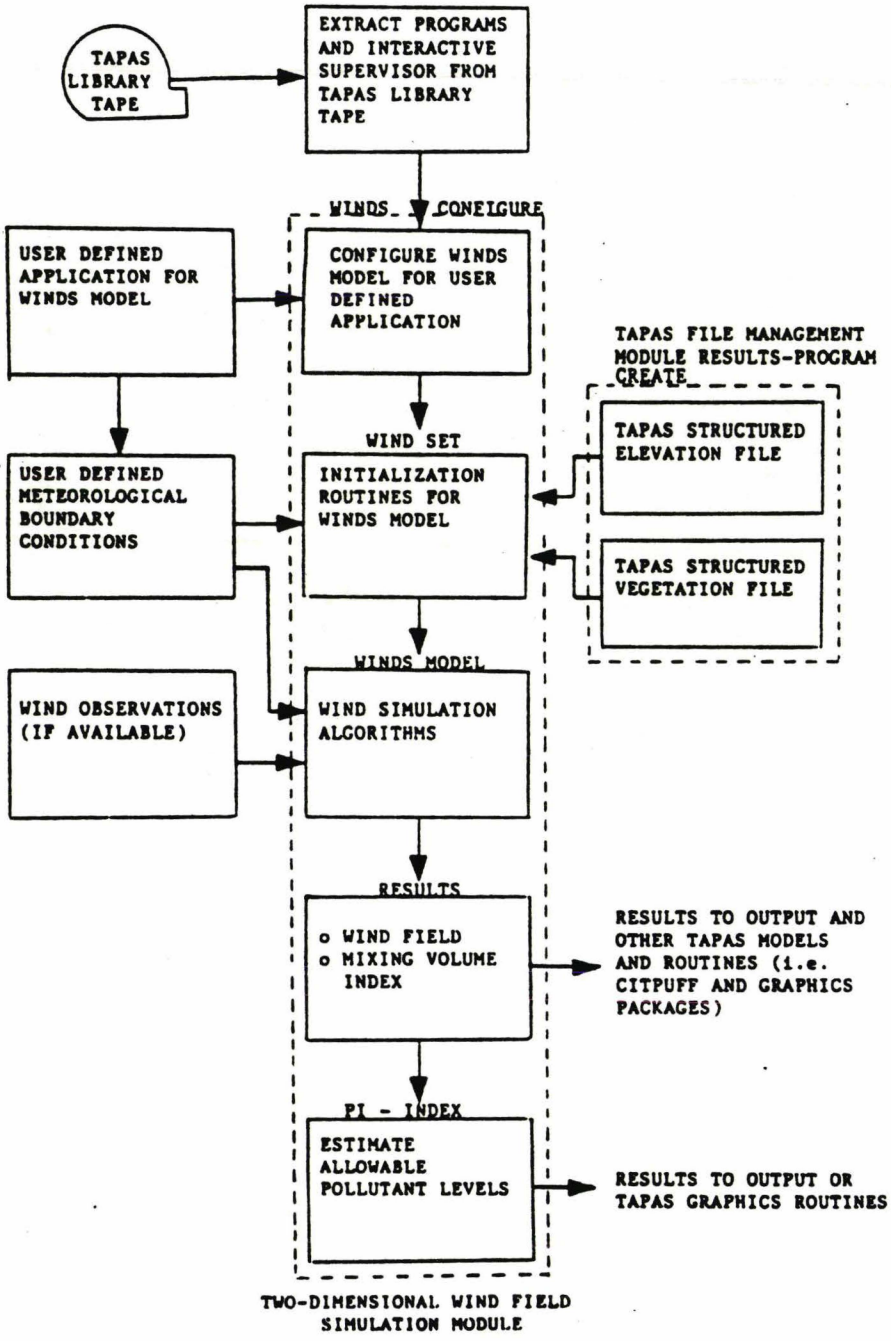
TAPAS LIBRARY TAPE
EXTRACT PROGRAMS AND INTERACTIVE SUPERVISOR FROM TAPAS LIBRARY TAPE
WINDS - CONFIGURE
USER DEFINED APPLICATION FOR WINDS MODEL
CONFIGURE WINDS MODEL FOR USER DEFINED APPLICATION
TAPAS FILE MANAGEMENT MODULE RESULTS-PROGRAM CREATE
WIND SET
TAPAS STRUCTURED ELEVATION FILE
USER DEFINED METEOROLOGICAL BOUNDARY CONDITIONS
INITIALIZATION ROUTINES FOR WINDS MODEL
TAPAS STRUCTURED VEGETATION FILE
WINDS MODEL
WIND OBSERVATIONS (IF AVAILABLE)
WIND SIMULATION ALGORITHMS
RESULTS
o WIND FIELD
o MIXING VOLUME INDEX
RESULTS TO OUTPUT AND OTHER TAPAS MODELS AND ROUTINES (i.e. CITPUFF AND GRAPHICS PACKAGES)
PI - INDEX
ESTIMATE ALLOWABLE POLLUTANT LEVELS
RESULTS TO OUTPUT OR TAPAS GRAPHICS ROUTINES
TWO-DIMENSIONAL WIND FIELD SIMULATION MODULE

Figure 2-5. TAPAS Two-Dimensional Wind Field Simulation Module Flow Chart.

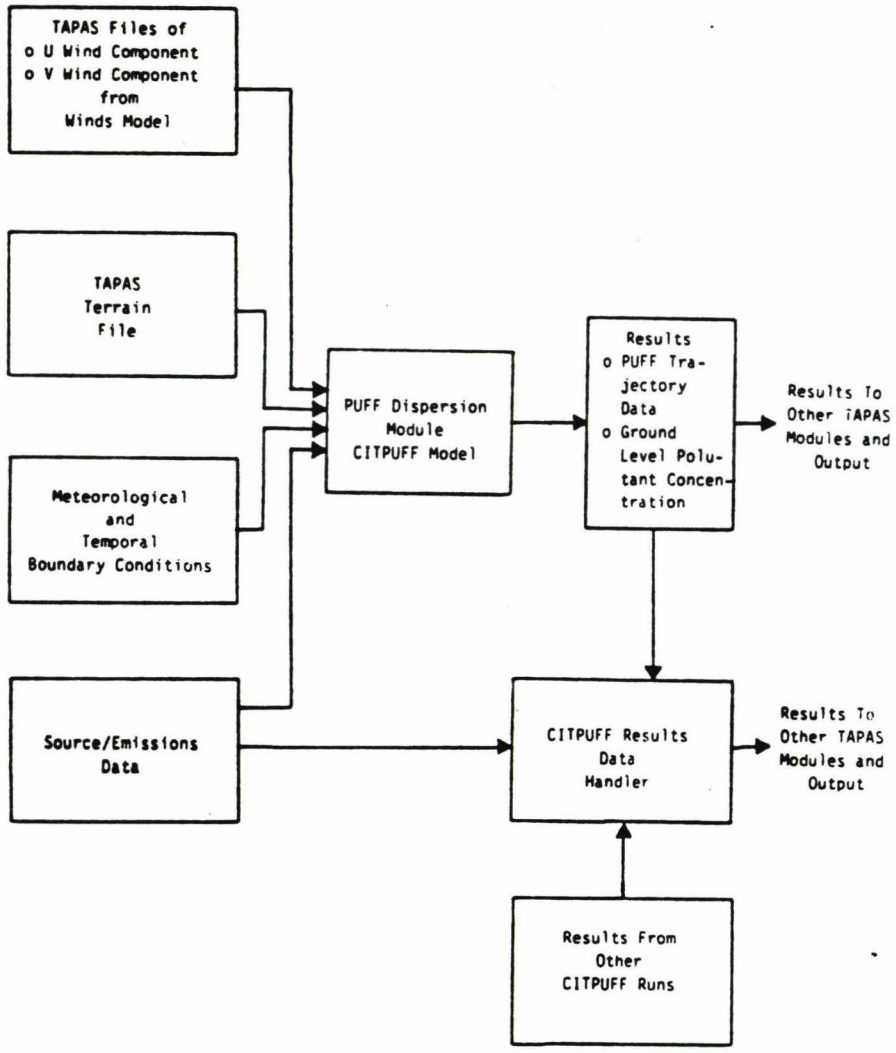

Figure 2-6. TAPAS Puff Dispersion Module Flow Chart.

user's guides that describe the application of module routines in detail:

CITPUFF: A Gaussian Puff Model for Estimating Pollutant Concentrations in Complex Terrain

User's Guide to the CITPUFF Results Data Handler Package

2.2.5 TAPAS Three-Dimensional Wind Field Simulation Module

The TAPAS Three-Dimensional Wind Field Simulation Module simulates a three-dimensional wind field in complex terrain. The ATMOS-1 model (Davis and Bunker, 1980) provides the basis for three-dimensional analyses. This model relies on terrain data, meteorological data and a variety of spatial and temporal boundary conditions. Results include wind vector grids for a number of atmospheric levels.

Figure 2-7 is a flow chart of the principal processes in the Three-Dimensional Wind Field Simulation Module. The TAPAS Three-Dimensional Wind Field Simulation Module User's Guide describes the application of the module in detail. The ATMOS-1 model is experimental and changes in the User's Guide for this module are expected as ATMOS-1 becomes better understood by TAPAS developers.

2.2.6 TAPAS Graphics Package Module

The TAPAS Graphics Package Module supports the production of graphic products associated with TAPAS. These graphic products are key to the efficient interpretation of the results from TAPAS routines.

The module contains eight principal graphic routines. A flow chart depicting the relationship among the routines is provided in Figure 2-8.

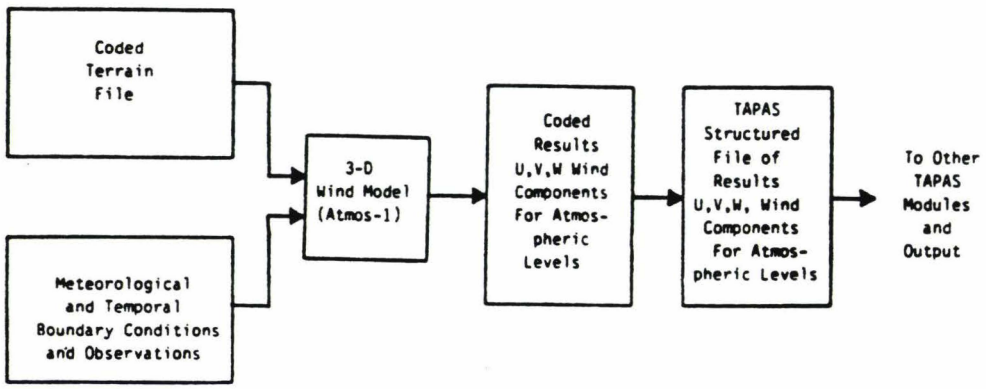

Figure 2-7. TAPAS Three Dimensional Wind Field Simulation Module Flow Chart.

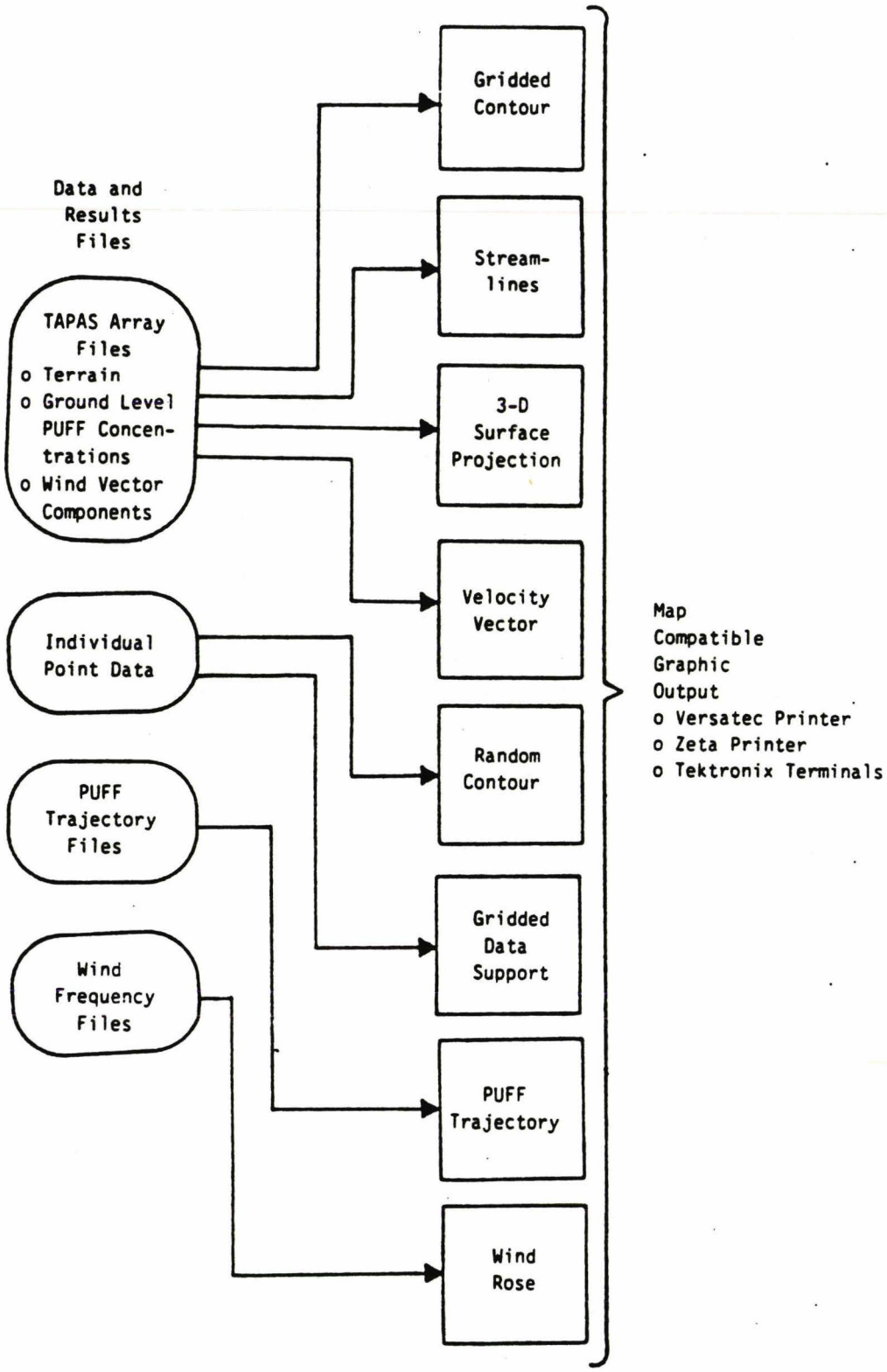

Figure 2-8. TAPAS Graphics Package Module Flow Chart.

The TAPAS Graphics Package User's/Programmer's Manual describes the general application of the TAPAS Graphics Packages. Separate, detailed user's guides have also been developed for each graphics package:

User's Guide to the Gridded Contour Graphics Package
User's Guide to the Gridded Data Support Package
User's Guide to the Random Contour Graphics Package
User's Guide to the Velocity Vector Graphics Package
User's Guide to the Puff Trajectory Graphics Package
User's Guide to the Streamlines Graphics Package
User's Guide to the Three-Dimensional Surface Projection Graphics Package
User's Guide to the Wind Rose Graphics Package.

2.2.7 TAPAS EPA Dispersion Module

The TAPAS EPA Dispersion Module supports the application of the EPA COMPLEX-I and COMPLEX-II air pollution dispersion models. The EPA recommends the use of the COMPLEX concept as one method to assess pollution dispersion in complex terrain. Only short term (i.e. 24 hour) applications in COMPLEX-I and COMPLEX-II are currently implemented within TAPAS.

A flow chart depicting the EPA Dispersion Module processing steps is provided as Figure 2-9. The TAPAS EPA Dispersion Module User's Guide describes the application of the module in detail.

2.2.8 TAPAS Meteorological Data Handler Module

The TAPAS Meteorological Data Handler Module supports TAPAS meteorological data requirements. This module will continue to be developed and expanded as operational meteorological requirements of TAPAS expand. Currently, the METWIX program is implemented within the module. METWIX summarizes meteorological observations and provides appropriate statistics of commonly measured meteorological variables

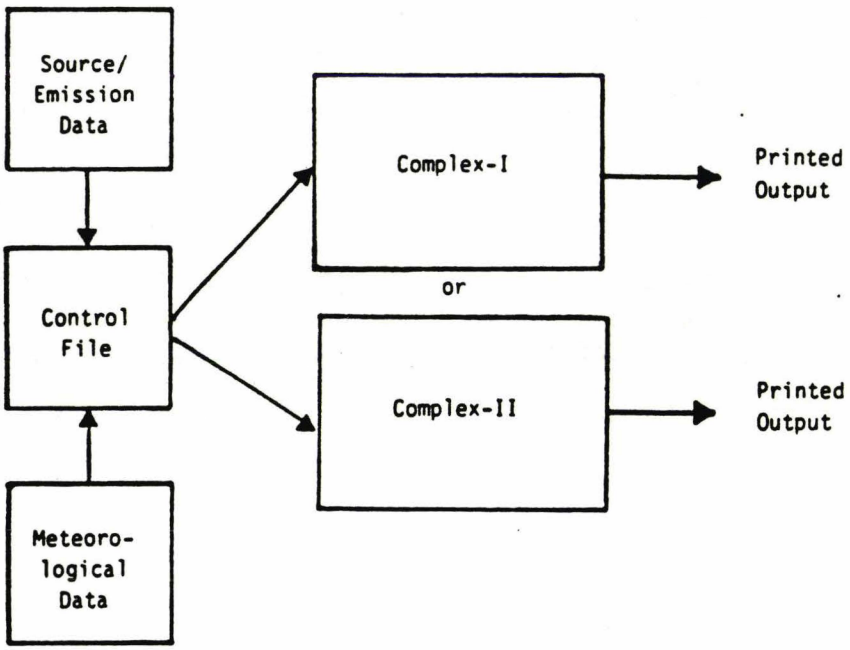

Figure 2-9. TAPAS EPA Dispersion Module Flow Chart.

including: temperature, relative humidity, wind speed and direction, and solar radiation. All program results are summarized in table printouts. Wind frequency distribution results are also available as a coded file compatible with the TAPAS Wind Rose Graphics Program.

A flow chart depicting the TAPAS Meteorological Data Handler Module (METWIX program) processing steps is provided as Figure 2-10. The User's/Programmer's Guide to the METWIX Program of the TAPAS Meteorological Data Handler Module describes the application of the module in detail.

2.2.9 TAPAS Visibility Screening Module

The TAPAS Visibility Screening Module supports the application of the EPA Level-1 visibility screening technique as outlined in the Workbook for Estimating Visibility Impairment (Latimer and Ireson, 1980). The Level-1 screening program is interactive and provides the user with ease and flexibility in the initial assessment of visibility impairment.

A flow chart depicting the Visibility Screening Module processing steps is provided as Figure 2-11. The TAPAS Visibility Screening Module User's Guide describes the application of the module in detail.

2.2.10 TAPAS Data Archive and Storage Module

The TAPAS Data Archive and Storage Module supports the file access, storage and maintenance requirements of TAPAS users. The module assists the user in retrieving and archiving working and library tape files. The module also supports the preparation of tapes for transport to other computer systems. The basis for the module is the Transport

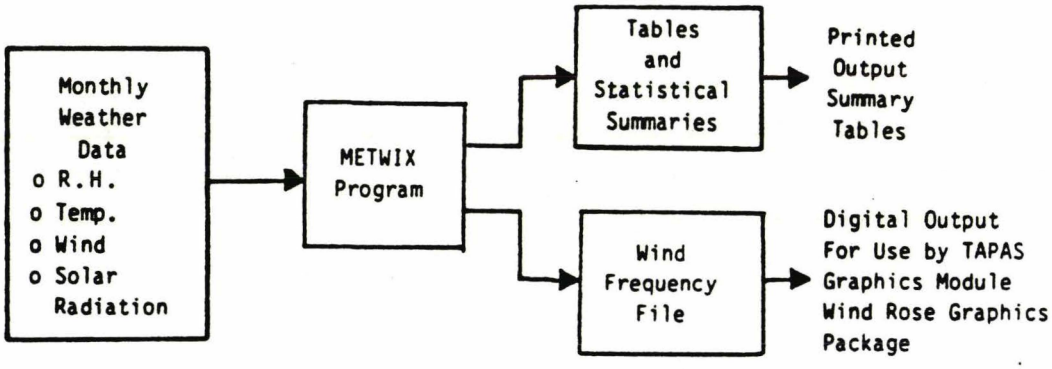

Figure 2-10. TAPAS Meteorological Data Handler Module Flow Chart for METWIX Program.

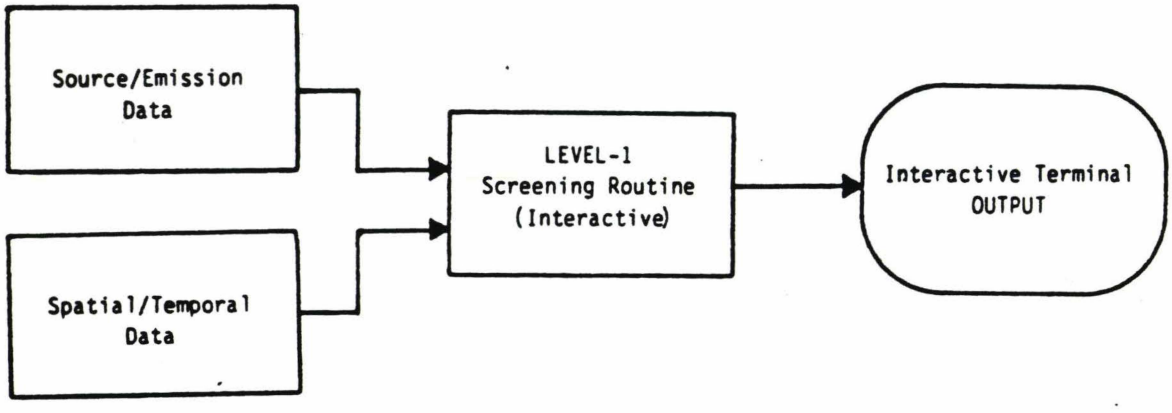

Figure 2-11. TAPAS Visibility Screening Module Flow Chart.

and Archive Tape System (TATS) developed by APCOMP, Inc. The system is designed to work on Control Data Corporation (CDC) machines.

Figure 2-12 is a flow chart that provides an overview of the TAPAS Data Archive and Storage module. The TAPAS Data Archive and Storage Module User's Guide describes the application of the module in detail.

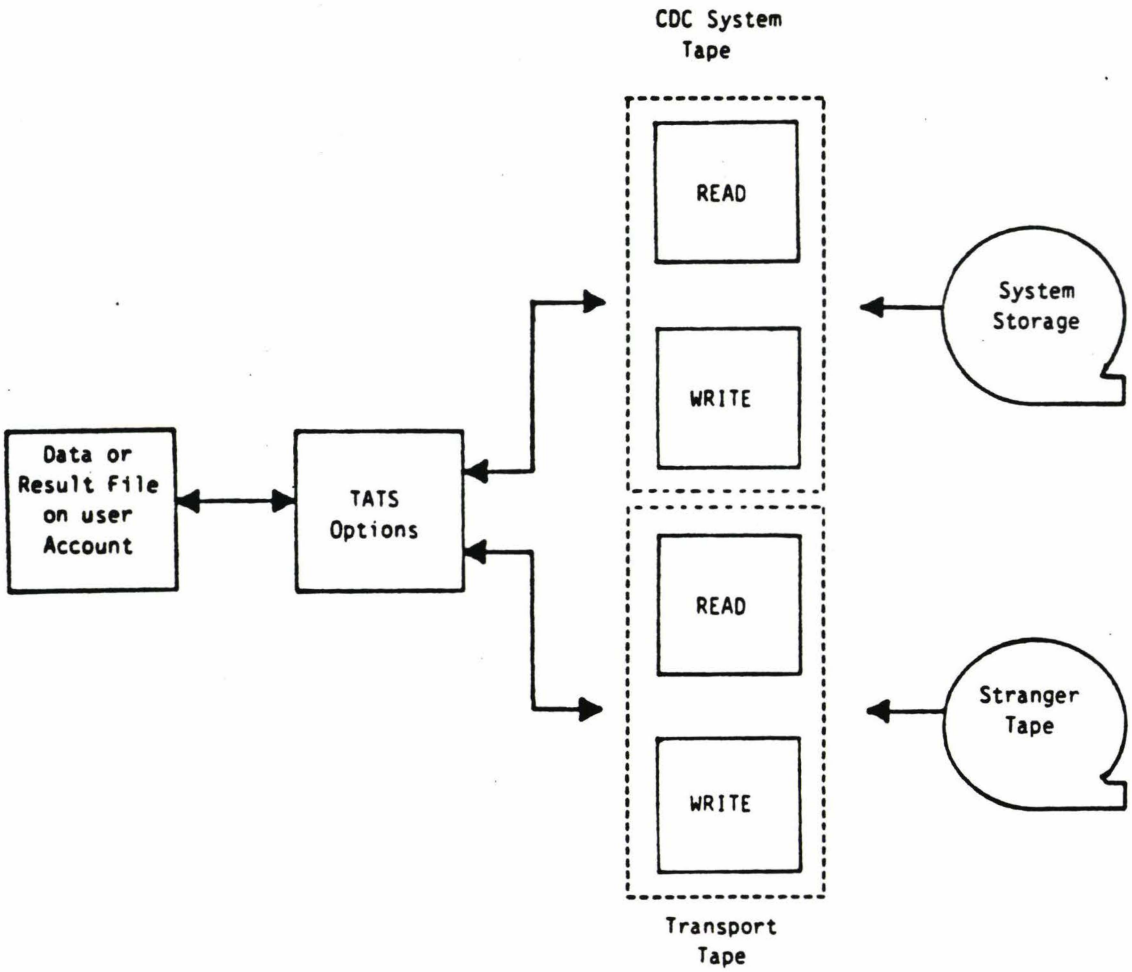

Figure 2-12. TAPAS Data Archive and Storage Module Flow Chart.

3.0 SYSTEM DEMONSTRATION AND TRAINING

A variety of demonstrations have been performed throughout the project to illustrate the operational capabilities of TAPAS. These demonstrations include:

- o COMPLEX-I Analysis and Training to Support a BLM Environmental Assessment for an Alunite Mine Near Clear Lake, Colorado
- o Comparison of CITPUFF to EPA COMPLEX-I and COMPLEX-II
- o Study of Observed and Modeled Air Quality Aspects of a Prescribed Sagebrush Burn
- o Pollution Dispersion Potential Analysis, Piceance Basin, Colorado
- o Operational Simulation of a WINDS and CITPUFF Analysis for Sacramento County, California

Each demonstration is briefly described in the following subsections. More detailed discussions of each demonstration, including graphic results, were delivered as technical notes or as a part of earlier interim reports to the project COTR. Each demonstration included hands-on training for one or more BLM or Forest Sevice personnel.

No affirmative direction regarding a more formal training schedule was developed during the project. Emphasis was therefore placed on responding to specific requests for operational demonstrations of TAPAS. These demonstrations will serve as effective examples for future training programs.

3.1 COMPLEX-I Analysis and Training to Support a BLM Environmental Assessment for an Alunite Mine Near Clear Lake, Colorado

The BLM needed to perform an initial air quality analysis for an environmental assessment (EA) of a proposed alunite mine near Clear Lake, Colorado. The EA air quality analysis provided an opportunity to combine training in the selection and use of modeling with performance of the EA analysis.

A scoping meeting was held to review the proposed mine plan, evaluate available data and select a modeling strategy. No meteorological data, emissions or other specific engineering detail was available on the mine beyond a proposed approach and several BLM alternatives. COMPLEX-I was selected as the appropriate model to perform the initial screening analysis for the EA.

Working with S. Archer of the Colorado State office of the BLM, available information on the proposed mine acreage disturbances and mining and transportation options were used to develop detailed emission inventories for six alternatives. The ground level TSP emissions were allocated to twenty-five map locations. TSP was the only significant pollutant identified.

A gridded receptor field was designed for evaluation of COMPLEX-I results. A ten by ten grid with a two minute spacing between grid points was used in this effort. Elevations for each grid point were extracted from 1:24,000 USGS contour maps. The elevations and all the source information were entered into COMPLEX-I data files.

Three of the six proposed mining scenarios were run using the COMPLEX-I model:

High Level with haul roads
Moderate Level with haul roads
Low Level without haul roads.

Each scenario was run for each of eight cardinal wind directions for three hour averaging periods. A total of 24 computer runs of COMPLEX-I were generated.

All results were incorporated by S. Archer into the draft EA (Archer, 1983). The modeling exercise was performed over several days and provided BLM personnel with an improved understanding of the way modeling can be used to assess potential air quality impacts.

3.2 Comparison of CITPUFF to EPA COMPLEX-I and COMPLEX-II

COMPLEX-I, COMPLEX-II, and CITPUFF were all applied to simulate ground level concentrations for theoretical flat and mounded terrain fields. The objective of the comparison was to define expected ranges of modeling results applied under identical conditions. A single source emission of 100 grams per second with an effective stack height of 300 meters (final plume rise) was assumed. An influencing wind of 4 m/s from the west (measured 10 meters above the surface) was chosen. A stable condition (Class E stability) was assumed for the comparison.

Both flat and mounded simulated terrain data were compiled for the test. The mounded terrain field consisted of two Gaussian shaped hills; one centered at 30 kilometers from the source and the other centered at 69 kilometers. For CITPUFF modeling, the terrain was defined within a x = 75, y = 21 grid, with a distance between grid

points of 1.5 kilometers. Receptors for COMPLEX-I and COMPLEX-II were located every 3 kilometers downwind to 99 kilometers from the source.

COMPLEX-I and COMPLEX-II were applied as recommended for regulatory purposes. The suggested configuration of COMPLEX-I and II (to conform to the EPA complex terrain concepts determined at the Chicago Workshop on Air Quality Models in 1980) includes the following:

1. Terrain adjustment factors (0.5, 0.5, 0.5, 0.5, 0.0, 0.0, for A through F stabilities).
2. Buoyancy induced dispersion.
3. Plume heights were not allowed to be closer than z_{min} (10 meters) to receptors.
4. Wind power law coefficients used in lieu of other justifiable site specific data (0.1, 0.15, 0.2, 0.25, 0.3, 0.3, for A through F stabilities).

A variety of CITPUFF configurations were tested. Three dispersion coefficient variations were applied; Pasquill-Gifford, PPSP and 22.5° (Ross et al., 1983). Additional variations that were considered included:

- Initial σ_y and σ_z of the point source emissions; and
- Puff release and sampling rate.

Results of the comparison indicate that beyond 50 km in both terrain tests, all model results fell within the range of centerline ground level concentrations defined by the low values estimated by CITPUFF (22.5° sector) and high values estimated by COMPLEX-II. Results from a recent EPA small scale field experiment suggest that COMPLEX-I ground level values may be more realistic than COMPLEX-II values. CITPUFF,

depending on the selected dispersion option, estimated both higher and lower values than COMPLEX-I and COMPLEX-II.

Significant differences in the treatment of plume interactions with elevated terrain also will lead to differences with model results. The maximum value predicted by CITPUFF for elevated terrain is also quite sensitive to the assigned values of initial dispersion coefficients and puff release and sampling rates.

The analysis provides the TAPAS user with the ability to evaluate CITPUFF results relative to EPA modeling techniques. A detailed presentation of the results was presented as a technical note to the COTR (Dietrich, 1983) and was included in the Second Interim Report for the Air Quality Technology, Research, Development and Demonstration for Land Management Needs project (Air Resource Specialists, Inc., 1983b).

3.3 Pollution Dispersion Potential Analysis; Piceance Basin, Colorado

A pollution dispersion potential analysis was performed for the Piceance Basin in Colorado. The objective of the dispersion potential calculation was to provide a regional assessment of potential near source effects due to ground level industrial emissions. The dispersion potential analysis can be used as a planning tool for industrial source siting.

The pollution dispersion potential analysis is based on modeled wind flow and mixing volume index calculations performed by the Topographic Air Pollution Analysis System, WINDS model. WINDS model analyses were run to simulate a stylized wind rose of the Piceance Basin. The mixing volume index results from the WINDS model runs were

combined by considering the frequency of occurrence of each modeled wind condition. The result was an annual pollution dispersion potential map of the Piceance basin.

Available stability wind rose data from the Piceance Basin was obtained by the BLM. Wind data from the Cathedral Bluffs Oil Shale Facility provided the most complete set of stability wind rose data. The data covered the period 3/1/75 to 2/28/76. Wind frequency distribution tables were available for A through F stability conditions.

The objective of this pollution dispersion analysis was to determine realistic worst case annual pollution dispersion in the Piceance Basin. The E-stability wind frequency distribution from Cathedral Bluffs was chosen as a representative data set upon which to base a realistic worse case analysis. The wind frequency distribution was reduced to sixteen wind directions by three wind speed categories.

WINDS model analyses were performed to simulate the wind flow for each category in the wind frequency distribution that was equal to or greater than 1% (thirty modeled wind categories). This modeling stylization of the wind rose accounted for 92.5% of the total wind frequency distribution.

Each WINDS model analysis yielded a pollution dispersion potential index value for each grid point in the analysis area. The index results from each of the thirty model runs were weighted by the frequency of occurrence of the modeled wind condition and combined into a composit pollution dispersion potential index. A map compatible graphic representation of the index was generated as a final product.

The results of the analysis were provided to S. Archer to support a resource management plan for the Piceance Basin. This type of regional index calculation may be used effectively as a planning tool to identify good industrial sites and potential problem areas.

3.4 Study of Observed and Modeled Air Quality Aspects of a Prescribed Sagebrush Burn

An important benchmark analysis for the demonstration of TAPAS was performed for a prescribed burn in northeast Nevada; the Holburn sagebrush burn site. The air quality/smoke management aspects of prescribed burning is an issue of concern to land management agencies. To evaluate the air quality related aspects of burning, a pilot investigation was designed and carried out in September 1983.

The test site, the Holburn Nevada burn, was selected from a series of potential burn sites being studied by the USDA Forest Service's Northern Forest Fire Laboratory in cooperation with the BLM. Using the burn prescription, a preliminary projection of wind flow and smoke plume transport was performed using TAPAS WINDS and CITPUFF models. The projection included a range of wind speed and direction categories.

The next step in the study was to document actual plume characteristics and meteorological conditions during the burn to provide a data set for evaluation of initial plume projections and to support a post burn simulation of the actual plume. Meteorological observations including surface and pi-ball measurements were taken on the day of the burn. Both 35 mm slides and 8 mm time-lapse photography were taken to document fire and plume dynamics from the ground. Aerial surveillance

during the peak of the burn was also conducted to quantify the plume dimensions and transport direction.

On the planned burn dates, weather conditions were less than ideal for the burn. After a few days delay, the forecast indicated that weather conditions would be marginally within prescription and the burn was attempted. Though ideal conditions never materialized, the burn attempt did provide a useful data set to investigate TAPAS capabilities for prescribed burn applications.

Using the collected information, a simulation of the plume representing the peak hour of the burn was performed. Comparison of the modeled preburn prediction and burn simulation with observations indicated that the TAPAS models could serve as useful tools in predicting prescribed burn plume transport characteristics.

The study was the first time TAPAS was applied explicitly to a fire situation. Though the results are promising, many quesitons remain in determining just how useful modeling techniques will be. Technical challenges with air quality/smoke management aspects include properly determining the smoke emission factors, plume rise, area source measurements, characterizations of the transport winds, and selection of proper dispersion factors. Use of management tools such as those applied in this study should lead to increased confidence in the utility of both measurement and modeling strategies.

The results of the Holburn study were summarized and presented at the Wilderness Fire Symposium in Missoula Montana (November 15-18, 1983) in a paper entitled "Wilderness Fire and Meteorology - Tools that are Available" (Fox et al., 1983).

3.5 Operational Simulation of WINDS and CITPUFF Analysis for Sacramento County, California

The Forest Service is participating with other Federal Agencies in a study of transport and dispersion modeling techniques. The test site for the analysis will be centered on Sacramento, California. To demonstrate the capabilities of TAPAS for near real time data analysis to support research planning and operational data collection on a research project, an operational WINDS and CITPUFF modeling exercise was performed.

Given a defined study area, basic meteorological regimes, a pollution source location and emission factors, a TAPAS analysis including WINDS and CITPUFF modeling was conducted. The total analysis was performed in approximately eight hours. This included definition of the model boundary conditions, extraction of terrain, WINDS modeling for three meteorological conditions, CITPUFF modeling for the same conditions, and generation of map compatible graphic overlays of all modeling results. The analysis also served as a training exercise for Forest Service personnel and a test of the utility of TAPAS documentation.

The analysis procedures and results of the analysis will be presented by D. Fox to the research group involved with the Sacramento area study in late January 1983.

This operational test of TAPAS demonstrated that the system has the capability to respond to near real time data analysis needs. In addition, the test illustrated how efficiently new users of TAPAS could learn to effectively apply the system to meet an analysis need.

3.6 Other TAPAS Analyses

Throughout the Air Quality Technology, Research, Development and Demonstration for Land Management Needs project, the TAPAS system was applied to support a variety of other resource related BLM and Forest Service requirements. These applications included wind and puff dispersion analyses to support Remote Automatic Weather Station (RAWS) siting in the Wind River/Bridger Wilderness and Routt National Forest, and wind and pollution potential mapping related to prescribed burning assessment in the Coconino National Forest.

The time and cost effective characteristics of TAPAS make it an attractive tool to support land management decisions. Increased use of the system will continue to yield a variety of new and useful analysis strategies that will help address land management challenges.

4.0 SUMMARY

The Air Quality, Technology, Research Development and Demonstration for Land Management Needs project (USFS Research Contract 28-K2-257) was conducted from October 1, 1982 through December 1983. The primary goals of the project included:

- o Develop an Analysis System based on the Topographic Air Pollution Analysis System (TAPAS)
  - Evaluation, modification, interactive implementation and documentation of wind, air quality dispersion and visibility models
  - Evaluation, modification, interactive implementation and documentation of TAPAS support software
- o Demonstration of the Fully Implemented TAPAS

These goals have been successfully met in this project effort.

The Topographic Air Pollution Analysis System consists of a variety of computer programs linked together to provide modeling tools to support the assessment of meteorology and air quality in complex topography. TAPAS couples physically based meteorological and pollution dispersion models with a system of input, processing, output and storage routines that can be easily applied and understood by the land manager. Results can be output as numerical printouts or as map compatible graphic products that can be used to support land management decisions.

TAPAS consists of ten analysis modules. Thorough documentation has been written for each module. This documentation includes user's instructions and example applications written with the land manager in mind. With appropriate training and by referring to the documentation, land managers familiar with the concepts of meteorology and air

quality will be able to apply TAPAS to meet research and operational needs.

TAPAS has been demonstrated and operationally applied to meet land management requirements. These applications have included:

- o assessment of air quality effects from proposed new industrial sources
- o evaluation of complex terrain wind flows to support RAWS stations siting decisions
- o determination of pollution dispersion potential for industrial source siting and prescribed burn planning
- o investigation of plume transport and dispersion from prescribed burns

The time and cost effective characteristics of TAPAS make the system an attractive tool to support land management decisions. The flexible modular design of TAPAS allows the system to accomodate new and better models and routines as they become available. Increased development and use of the system will continue to yield a variety of new and useful analysis strategies that will help address land management problems.

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